Effects of Benthopelagic Animals on Seabed Properties

D.V. Holliday
Marconi Aerospace
Analysis and Research Division
4669 Murphy Canyon Road
San Diego, CA 92123-4333
Phone: (619) 268-9777 FAX: (619) 268-9775 email: holliday@tracor.com

C.F. Greenlaw
Marconi Aerospace
Analysis and Research Division
4669 Murphy Canyon Road
San Diego, CA 92123-4333
Phone: (619) 268-9777 FAX: (619) 268-9775 email: cgreenlaw@tracor.com

D.E. McGehee
Marconi Aerospace
Analysis and Research Division
4669 Murphy Canyon Road
San Diego, CA 92123-4333
Phone: (619) 268-9777 FAX: (619) 268-9775 email: dmcgehee@tracor.com

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LONG-TERM GOAL

The long-term goals of this research are to improve the ability of benthic biologists and biological oceanographers to observe life on and in the seabed; to describe the interactions between the animals that live there, their neighbors and their food; to improve our understanding of the coupling between the benthic and the pelagic communities; and to assess biologically mediated changes in those physical properties of the seabed that affect the scattering and penetration of sound from and into the bottom.

OBJECTIVES

Direct observation of animals that live on or in the seabed is exceptionally difficult. This is especially true in areas with characteristically poor visibility or in water that is too deep to allow divers to spend much time near the bottom. Little attention has been given to developing instrumentation and sensors that would allow remote observation of benthic animals for long periods at high spatial and temporal resolution. Our short-term and medium-term objectives involve developing high frequency acoustic sensors to fill this gap, thereby improving the information that benthic ecologists can access about benthic and benthopelagic animals and the seabed environment.

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APPROACH

Most work on the scattering of sound from the bottom, and from the animals that live there, has used acoustical frequencies of a few kHz or at most, a few hundred kHz. We are attempting to enhance the tools that operate in the tens and hundreds of kHz and to extend this range into the MHz frequency range. The advantages of doing this involve the availability of more bandwidth at the higher center frequencies. There also is likely to be information in backscattering levels when measured over a wide spectrum of frequencies. Ultimately, range resolutions of a few centimeters (along-beam and cross-beam) are achievable. This would allow tracking of individuals over areas of tens of meters around a fixed location, or the development of very high resolution towed devices to be used to survey larger areas.

Our immediate work involves testing some of our prototype instrumentation and using some of our more mature sensors during an ONR-sponsored field experiment in the Gulf of Mexico during October and November of 1999. This experiment, the Sediment Acoustics eXperiment (SAX-99), is jointly sponsored by ONR's biological oceanography, geophysics and acoustics groups. Our specific part of this work principally involves monitoring the emergence and re-entry of small benthopelagic crustaceans at dusk and dawn. This behavior is thought to change the roughness of the seabed at millimeter scales twice a day. Changes in bottom currents can also trigger these behaviors (Roman, Holliday, and Sanford, submitted). Animals may also burrow into the seabed, thereby changing the volume heterogeneity of the subsurface in the upper meter or two. These two phenomena are possible contributors to an observed anomalous penetration of the seabed by sound in the kHz and tens of kHz frequency range. A sample record from one of our TAPS, a multi-frequency upwards-looking echo sounder, is provided in the results section below to illustrate this phenomenon. We are also preparing to measure the scattering of sound from the seabed frequencies from about 2 kHz to about 20 kHz in order to assess the coherence the behavior of the local benthopelagic populations and changes in scattering from the seabed. We are being assisted in the deployment of our acoustical suite of instruments and in the collection of ground truth information by Pete Jumars (University of Maine) and his staff (University of Washington).

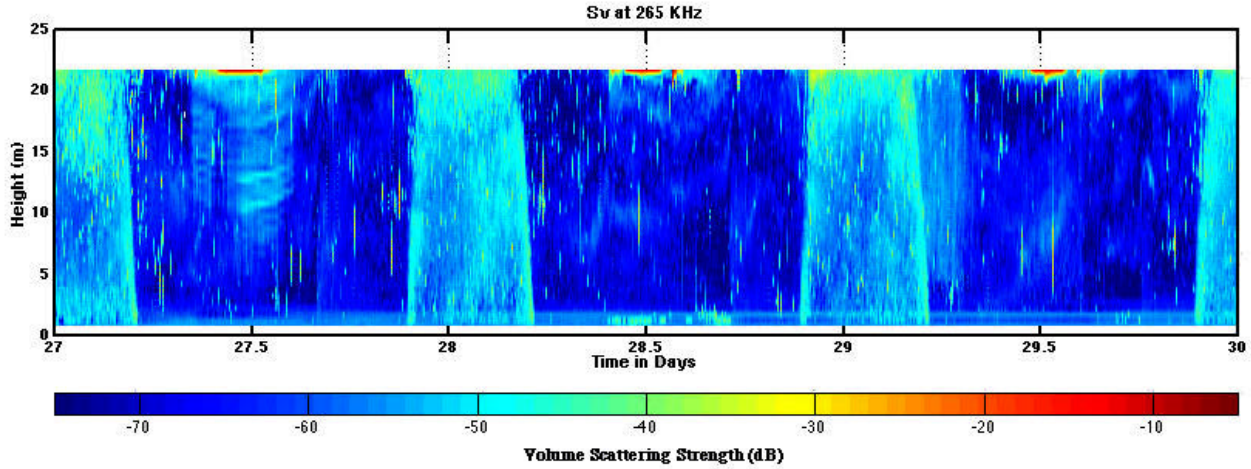
WORK COMPLETED

We have built several new acoustical sensors and have adapted several existing ones to the tasks we will need to accomplish during the fall SAX-99 experiment. The preparation of an automated data collection software package is essentially complete. We are now working on analysis and display software and on the control software for a spread spectrum telemetry system that we will be using to collect and store the data in real-time.

RESULTS

As the field work is about three weeks away, documenting the results of this work is a bit premature. However, the illustration below, from a prior project in West Sound, WA during the summer of 1996, illustrates the phenomena of emergence and re-entry of small benthopelagic animals. In this case, some

of the animals were caught in emergence traps placed at the site by Peter Jumars and his staff. The animals that we suspect contributed to the patterns of migration shown were mysids, which are known to exhibit this kind of behavior. The TAPS transducer faces were only a few centimeters above the muddy bottom in this shallow fjord.



IMPACT/APPLICATION

Observation of aquatic animals in their natural environments remains a major challenge in both biological oceanography and limnology. Critical processes in feeding, reproduction, growth and predation occurs at scales from fractions of millimeters up to scales which match the ambits of individuals. We believe that high frequency, high resolution acoustical sensors can play a part in improving our ability to sample and observe benthic animals and the benthic environment. This should be particularly so in environments where visibility is limited by either resuspension or by a nephaloid layer. Sound also has the advantage that it can penetrate the seabed, making possible observations of near surface animals and the structures that they build in the bottom.

The seabed and the zone that lies immediately below the bottom is a dynamic environment, not a static one. Both physical processes and biological ones play important roles in the degree of consolidation of the sediments, the heterogeneity of the bottom and the changes that take place over different temporal scales. These processes impact the seabed properties which control acoustic scattering , the coupling of sound into the bottom, and the propagation of sound along the surface and in the bottom. All of these phenomena potentially impact Naval operations in shallow water, where mine warfare and ASW operations must be conducted prior to engaging in expeditionary warfare.

TRANSITIONS

During the field work in the Gulf of Mexico, we will be training a benthic ecologist (Dr. Jumars) in the use of a TAPS to detect fluxes of small benthopelagic animals. We will also be monitoring our instruments for the occurrence and timing of emergence and re-entry events for benthopelagic

crustaceans at the SAX-99 site. We will be providing the results of our observations to all of our co-principal investigators in this program.

RELATED PROJECTS

In the context of a special Departmental Research Initiative on High Frequency Scattering from the Seabed, ONR Code 32 has formed a team of principal investigators from multiple institutions to examine the reasons for observed anomalous sound penetration into the seabed. A field experiment will be conducted in the fall of 1999, off Panama City, FL to examine this acoustical phenomenon in detail and to attempt to relate the observations to the physical and biological environment. Participating institutions include: NSWC CSS, the University of Washington (APL & Oceanography), Marconi Aerospace (AARD), the University of Texas (ARL), the Scripps Institution of Oceanography (MPL), NRL/SSC, PSI, Columbia University (LDEO) and Oregon State University.

REFERENCES

Barans, C.A., B.W. Stender, D.V. Holliday and C.F. Greenlaw. 1997. "Variation in the vertical distribution of zooplankton and fine particles in an estuarine inlet in South Carolina", Estuaries 20(3): 467-482.

Roman, M.R., D.V. Holliday and L.P. Sanford, "Temporal and spatial patterns of zooplankton in the Chesapeake Bay Turbidity Maximum", Mar. Ecol. Prog. Ser. (submitted).

PUBLICATIONS

Holliday, D.V., R.E. Pieper, C.F. Greenlaw and J.K. Dawson. 1998. "Acoustical Sensing of Small Scale Vertical Structures in Zooplankton", Oceanography 11(1): 18-23.